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ABSTRACT

A study was conducted by the Air Force to determine the extent to which takeoff/landing skills learned in a simulator equipped with a night visual system would transfer to daytime performance in the aircraft. A transfer-of-training design was used to assess the differential effectiveness of simulator training with a day versus a night computer-generated image (CGI) visual display. Twenty-four novice student pilots were divided into three groups: day, night, and control. The day and night groups received three training missions in the Advanced Simulator for Pilot Training (ASPT) on takeoff, straight-in approach and land, and touch-and-go. The control group received standard syllabus instruction (that is, no ASPT). Transfer to the aircraft was assisted by instructor pilots on two aircraft sorties performed during daylight conditions. Results of the study indicated that (1) student performance improved significantly on the takeoff, full stop straight-in, and the takeoff portion of the touch-and-go; (2) there were no differences between the day and night groups as assessed by instructor pilot performance ratings; and (3) there was no tendency for performance to be differentially influenced by the differences in day and night scenes. (Author/LLS)

AFHRL-TR-79-56

AIR FORCE

HUMAN RESOURCES

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COMPUTER GENERATED IMAGE:
RELATIVE TRAINING EFFECTIVENESS OF DAY VERSUS NIGHT VISUAL SCENES

By

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Final Report

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NOTICE

This final report was submitted by Operations Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, Arizona 85224, under project 1123, with HQ Air Force Human Resources Laboratory, Brooks Air Force Base, Texas 78235. Dr. Elizabeth L. Martin was the Principal Investigator for the Laboratory.

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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PREFACE

This effort was conducted by the Operations Training Division, Air Force Human Resources Laboratory, Williams AFB, Arizona. The research was completed under Project 1123, USAF Flying Training Development, Mr. James F. Smith, Project Scientist, and Task 112303, the Exploration of Simulation in Flight Training, Mr. Robert Woodruff, Task Scientist.

The conduct of the research was supported by the 82d Flying Training Wing (ATC), Williams AFB, Arizona. The support rendered by the members of the 82d FTW Deputy for Operational Research Staff during the simulator training of the students is greatly appreciated.

Invaluable assistance was rendered by Mr. Richard Greatorex (Flying Training Division, Air Force Human Resources Laboratory) in the data retrieval and data analyses computations.

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I. INTRODUCTION

The Air Force is in the process of increasing its simulator training capabilities for most weapons systems to inclnde contact/visnal flight training. In some cases, entirely new simulators are being designed; in other cases, existing devices are being improved. In either case, an important area of consideration is the choice of a visnal display system. Numerous options for simulator visual systems are commercially available. Major system types include TV Model Board, Compnter-Generated Image (CGI), and Point Light Source systems. Across and within each system type, a variety of choices can be made with respect to acqnisition costs and the ability to meet training objectives. Although information is available to specify system costs, little information is available to determine training benefits.

The research was undertaken to determine the extent to which takeoff/landing skills learned in a simultor eqnipped with a night visnal system would transfer to daytime performance in the aircraft. The possibility that learning to fly with the aid of a night visnal scene simulator would result in flying habits and strategies specific to nighttime flying raises questions regarding the extent and direction of training transfer that can be expected for daytime flight training. An area of particular concern is in the critical stages of flight where any negative transfer might be particularly hazardous, especially for the novice pilot. However, if snbstantial positive transfer could be achieved nsing a night scene (at least comparable to other types of displays), considerable cost savings conld be realized. Training effectiveness data are needed in order to supply information reqnired in a cost-to-benefit analysis model, particnlarly when the choice is between an add-on or retrofit modification to an existing device versus procnrement of an entirely new device.

Background

Additional hazards are associated with night flying and have been well docnmented in the aviation literature. In addition to vertigo and spatial disorientation, poor final approaches have a higher probability of occnrrence at night. In a snrvey conducted for the Navy, Simons (1965) reported a day/night carrier landing accident ratio of 1:4. In snbsequent research on day/night carrier approaches, Brictson (1966) reported that pilot tended to fly lower approaches and to land longer and softer at night than by day. The most revealing measures were those of variability, with the standard deviations of the night approaches more than twice that of the daylight approaches. This situation resnlted in the necessity of attempting to make large corrections in the final stages of the approach, an obviously undesirable predicament.

Although the problems with night landings may be more critical for the carrier situation, they are of no less concern to the general aviation community. The specific behavioral problems may differ between carrier landings and runway landings (Lewis & Humphries, 1956), but one trend is consistent. pilots fly lower with much greater variance in their night approaches. The tendency to land short on runways as opposed to long on carrier decks has been reported in the safety literatnre. It is not clear whether this is actually representative of typical night approaches or whether it is only representative of the unsuccessful ones.

The pilot's inability to make accurate judgements of altitude, sink rate, and rate of closure was identified as a major contributing factor in many pilot-error landing accidents (Zeller, 1957). At night, the difficulty of making these judgements is increased due to the absence or degraded nature of the environmental cues. This situation has led to the development of many runway and cockpit landing aids. However, the last portion of the approach is dependent on visual flight restructions and pilot judgement.

Advances in modern visual display systems have made it possible to simulate a variety of environmental conditions including night scenes. It is now possible to practice night flying in the safety of a simulator. It is also possible (a) to study problems involved in night flying, (b) to determine the visual cues required for effective simulation, and (c) to develop effective training techniques aimed at increasing transfer benefits and safety.

Research efforts have begun in an attempt to improve visual scene content and to define the training value of various visual display systems. Kraft, Anderson, and Elworth (1977) has demonstrated that pilots tend to overestimate their altitude when lights in a computer-generated night scene have equal luminance, regardless of distance. The flightpaths under these conditions were significantly lower than when the luminance of the lights was attenuated. The overestimation of altitude was greatest when no texturing cues were added to the overrun and runway scenes. Kraft et al. (1977) also reported that runway position at touchdown improved with practice with the attenuated luminances hut that the luminance and texturing variables did not result in improved rate of descent at touchdown.

Buckland (1979) has investigated the landing performance of experi- enced pilots in the Advanced Simulator for Pilot Training (ASPT) under various detail and texturing conditions. Two of the conditions included night scenes similar to the one used in the present study. The results indicate that night scene touchdowns were harder than any of the day scene conditions. The night scene touchdowns were also farther from the threshold than were the average day scene touchdowns. Buckland also reported that the touchdown vertical velocity values were substantially larger for all of the scene conditions than for actual flight data. This finding is consistent with the results reported hy Palmer and Cronn (1976) in a study of touchdown performance in a DC-8 simulator equipped with a night computer graphics visual attachment. The authors also reported that the vertical velocity values obtained in their study were approximately 10% to 20% lower than values obtained in an earlier experi- ment using a TV model system (Bray, 1972).

The primary intent of the previously cited research was to study the characteristics of night (real or simulated) flying and the problems associated with night flying. More directly relevant for the purposes of the present study is research dealing with transfer of training from night scene simulation to daytime aircraft flight. To date, only two studies have addressed this issue: (a) the Navy (Brictson & Burger, 1976) conducted an evaluation of the A-7E Night Carrier Landing Trainer (NCLT) which is equipped with a night visual scene, and (b) the Air Force (Thorpe, Varney, McFadden, LeMaster, & Short, 1978) conducted a comparative evaluation of three visual system types for possible application in the KC-135 program. In the transfer-of-training evaluation of the Navy A-7E NCLT conducted by Brictson and Burger (1976), half of the subjects received 80 NCLT approaches prior to actual flight training. Their performance was compared with a control group of pilots who did not receive NCLT approach training. Transfer evaluations were made both during the field carrier landing training and carrier qualification phases on both night and day approaches. Measures of performance included radar reading, landing signal officer scores, success/attrition rate, wire arrestment, bolter rate, and landing performance scores. The results indicated that NCLT training resulted in significantly better performance on night approaches, particularly on vertical path control, had more impact for new pilots than for pilots with other aircraft backgrounds, and resulted in significantly lower attrition rates (8% vs 44%). However, the NCLT

training did not improve performance on daytime approaches, and this is the most important finding for the present study since it shows the transfer of training was specific to the nighttime environment and did not generalize to the daytime condition.

Thorpe et al. (1978) conducted a transfer of training experiment comparing three visual systems: a TV Model Board, a Daylight Color CGI, and a Night-Only Point Light Source CGI. Three groups of pilots recently graduated from the Undergraduate Pilot Training (UPT) program received simulator training on the visual traffic pattern, approach, and landing using one of the three visual systems (using Boeing 707 aircraft simulators rented from commercial flight training sources). Following the simulator training, the pilots flew two evaluation flights in the KC-135 aircraft in daylight conditions. Although there were no significant differences observed during the simultor training, the results of the evaluation flights indicated that the pilots in the Day Color CGI Group and the Night-Only CGI Group performed better on the final approach glidepath and landing portions of the task than did the pilots trained with the TV Model Board system. The latter group exhibited more extreme deviations from the glidepath, especially lower glidepaths during the final third of the approach than did the other two groups. A follow-up comparison of their scores in the CCTS program revealed that a higher percentage of pilots in the Day Color CGI Group received "Highly Qualified" (90%) scores than did those in the Night (50%) or TV Groups (40%). Only 30% of normal CCTS students received this grade.

Thus, while there are simulator performance data and subjective opinions indicating that CGI systems (both day and night) lack adequate cues for altitude, sink rate, and closure rate estimation, the only transfer-of-training research data available indicate that the CGI systems (color day and point light night) are at least capable of supporting daytime training, and may be superior to the TV model board. The Navy study demonstrated positive transfer from night simulator training to night carrier approaches, but no effect was observed for transfer to day approaches. Equally important for the purposes of this report is the finding that no negative transfer was evident in the performance of the night group on subsequent day performance in either study.

The Problem

The Air Training Command has recently introduced a new ground-based flight trainer, the Instrument Flight Simulator (IFS), into the UPT program. Although its primary purpose is to support instrument skill acquisition, a secondary purpose is to support limited contact training objectives. Currently, half of the IFS cockpits are equipped with a look-ahead field-of-view TV terrain model board visual system. Prior to making any further procurements for the remaining cockpits, the Air Training Command requested an estimate of the amount of transfer of training which could be achieved with a dusk/night limited field-of-view visual system. The use of such a visual system could result in significant cost savings if there was no loss in training effectiveness. Of particular interest was the issue of negative transfer potential in the critical phases of flight, i.e., the takeoff and landing area. The present research was undertaken to answer this question, as well as to provide a comparison between the relative effectiveness of the ASPT CGI day scene with the night scene.

II. METHOD

General Approach

A transfer-of-training design was used to assess the differential effectiveness of simulator training with a day vs. a night CGI visual display. Twenty-four novice student pilots were divided into three groups: Day, Night, and Control. The Day and Night groups received three training

missions in the ASPT on Takeoff, Straight-In Approach and Landing, and Touch-and-Go. The Control group received standard syllabus instruction (i.e., no ASPT). Transfer to the aircraft was assessed by Instructor Pilots (IPs) on two aircraft sorties performed during daylight conditions.

Subjects

Twenty-four student pilots participated in this study. Twelve students each were selected from UPT Class 78-02 and 78-03. The following descriptive information characterizes the sample: (a) Source of commission — 11 Reserve Officer Training Commission, 13 Air Force Academy graduates; (b) no previous navigator experience; (c) $\overline{X}$ age =22.8 (s.d. 1.12, range 22—27); (d) previous simulator experience, $\overline{X}$ =0.25 hours (s.d. 0.84, range 0—3) and (e) previous aircraft experience, $\overline{X}$ =32.7 hours (s.d. 17.8, range 16.2 — 40). None of the students had previous jet aircraft experience.

Instructor Pilots

Four experienced T-37 IPs served as simulator instructors during the pretraining phase of the study. The flight instructors normally assigned to the students served as data collectors during the aircraft portion of the study; none of the ASPT instructor pilots participated during this phase.

All participating flightline instructors received familiarization training in the ASPT on data collection procedures to be used in the aircraft. This training consisted of a verbal briefing followed by practice in data taking in the ASPT. Each IP viewed two performances of a Takeoff, Full Stop Straight-In Approach and Landing, and a Touch-and-Go. One performance was representative of an experienced T-37 IP and the other of a novice pilot. These performances were prerecorded and stored for demonstrations; thus, each pilot viewed the same set of maneuvers. The instructors were thoroughly debriefed, and definite errors were clarified. The IPs were also given a written information sheet to serve as a refresher prior to inflight data collection (see Appendix B). The entire training period was approximately 1.5 hours in length. The training was given 10 days prior to the actual aircraft data missions.

Equipment

The ASPT research equipment provides a wide range of capabilities not previously provided in any one simulator. A complete description of ASPT is presented in Gum, Albery, and Basinger (1975). An overview of the aspects of the ASPT most relevant to the present study is presented in this section.

The ASPT is equipped with two T-37 cockpits. Each cockpit has a full field-of-view visual display (300° horizontal by 150° vertical), a CGI visual system, a six-degrees-of-freedom (DOF) synergistic platform motion system, and a 16-panel pneumatic G-seat on the left seat (student position).

The visual display is projected through seven cathode ray tubes (CRTs). The capacity for displaying visual image detail is fixed and shared between the two cockpits. A highly detailed scene, such as an airport, requires 90% to 100% of the display capacity; thus, at the most, only 10% of the capacity would be available to the other cockpit. This amount would result in inadequate representation of a highly detailed scene but is adequate to display a generalized view from altitude such as a horizon and surface texture pattern. The visual system uses an infinity optics display with the exit pupil located at the student's eye position. This arrangement results in an optimal visual scene from the student position, but a distorted scene from the IP position. From a normal position,

the IP is unable to see the visual display immediately in front of the aircraft. The scene becomes less distorted as the IP scans laterally. By moving the head position nearer to that of the student's, the IP can increase the forward looking view and reduce the distortion.

The platform motion system is driven by six hydraulic actuators, each with a travel capability of 60 inches. The platform motion system software was designed to provide translational and rotational acceleration onset cues to the student pilot position. The G-seat can also display sustained accelerating cues: however, the G-seat was not used in this study and will not be discussed. The motion system also includes a special effects package which is used to display such cues as touchdown bump, runway rumble, aircraft buffet, speedbrake extension, and gear-down rumble.

The ASPT has the capability of real-time automated measurement of the pilot's performance. Measurements can be made of pilot inputs, system outputs, and scores can be derived from these measures. The measurement schemes or algorithms for a given maneuver can be preprogrammed. An entire sortie content can be preprogrammed with automated performance measurement taking place on predesignated trials. A limited amount of this information can be displayed real-time in the cockpit via a monitor located to the right of the IP position and/or following the mission in hard copy form.

The ASPT is equipped with the capability of displaying a prerecorded demonstration of a maneuver. The information is stored on disc and replay involves reproduction of the entire maneuver as originally recorded, including visual display, motion cues, instrument readings, rudder and throttle movements. Both the students and the IPs utilized this capability during the pretraining and ASPT phases of this study.

Visual Display

The data base developed for the night visual study consists of a night airport traffic area configured to closely approximate the McDonnell-Douglas Vital III display and equivalent day airport traffic area.

A computer-controlled mask restricted the field of view to 48° horizontally and 36° vertically. A generalized airport scene was created with one model depicting the night scene and another model depicting the day scene. For the night scene, the environment included a 6,000-foot lighted runway with approach lighting and runway markings. The runway centerline was visible for 1,000 to 2,000 feet in front of the aircraft on the runway, with touchdown zone stripes at the approach end of the runway. Inset runway lights were also provided to simulate the runway lighting of the McDonnell-Douglas Vital III system. There were base lights randomly positioned out to 10,000 feet on both sides of the runway and from 10,000 feet out from the departure end of the runway. Horizon lights were also randomly positioned at a further distance, providing the appearance of convergence as the aircraft descended to lower visual approach angles. Horizon glow was added providing a dusk/night scene. Other visual details included a cube tower with rotating beacon on top, offset 5,000 feet to the left of the runway. There were two radio towers offset 3,000 feet to the right of the runway and two light towers on the right side of the runway offset 2,000 and 1,000 feet from the end of the runway.

The day scene consisted of a fully marked 6,000 foot runway with runway edge lights and sequenced flashing approaching the runway. Low level velocity and altitude cue enhancement was achieved through the use of numerous three-dimensional features in this area. On final approach, there was a drive-in movie theatre and an agricultural area consisting of a church, farm buildings, pickup truck, wagon, and tractor with plow. The control tower and other buildings were adjacent to the runway, with a factory in the background, and at the threshold, a T-37 aircraft was waiting to take the active runway.

Student Training

Following selection for study participation, the subjects were randomly assigned to one of three groups: Day, Night, or Control. Subjects in the Control group did not receive any ASPT pretraining prior to entry into the T-37 flying phase. Students in the two experimental groups received three ASPT sorties in which instruction was given on Takeoffs, Full Stop Straight-In Approaches, and Straight-In Approaches to a Touch-and-Go Takeoff.

The visual field of view was limited to 48° horizontal by 36° vertical by a computer-generated mask. This was essentially a look-ahead view designed to represent the field-of-view available on the IFS in use by the Air Training Command. The ASPT syllabus consisted of three sorties, each approximately one hour in length. The first and second sorties were separated by a 48-hour interval, with the second and third sorties occurring in daily succession. The content of each sortie was specified in terms of the number of repetitions per task and task order. The ASPT syllabus is presented in Appendix A. A total of 13 Takeoffs, 13 Straight-In Approach/Landings, and 9 Straight-In Approach/Touch-and-Go maneuvers were performed. Following completion of the three ASPT missions and standard syllabus requirements, the students began flightline training. The desired time between the last ASPT mission and the first aircraft flight was 1 day; however, in some cases the interval was as long as 3 days because ASPT training was completed on a Friday.

Transfer Evaluations

The first T-37 aircraft flight was conducted as specified in the standard UPT syllabus with the proviso that a demonstration of a Takeoff, Straight-In Approach, and Full Stop Landing and a Straight-In Approach to a Touch-and-Go Takeoff was given by the IP with no "hands on" practice by the student.

The second and fifth T-37 flights served as the data collection missions for all three groups. The IPs were asked to design each mission to include at least one hands-on repetition by the student of the Initial Takeoff, Straight-In Approach to a Touch-and-Go, and a Straight-In Approach to a Full Stop. Performance evaluation data were to be recorded on each task by the IP as soon as possible following task completion. In the event that more than one repetition of any of the tasks was performed, the IP was asked to collect the desired data on these additional repetitions as well. The IP was asked to refrain from instructing during the performance of each task; however, in no case was the safety of the flight to be compromised. In the event that the IP had to take control of the aircraft, only the portions of the flight flown by the student were to be recorded.

Dependent Measures

Performance measures of two types were collected on each trial designated as a measurement trial. (No performance measures were collected on the remaining trials.) Root-mean-square error measures were collected on each task parameter which had a criterion-referenced objective

In addition to the objective automated measures, subjective performance ratings were obtained from the IP. The basic rating scale was the same used in the normal ATC training program. This scale specifies standards for each grade of U (Unsatisfactory), F (Fair), G (Good), and E (Excellent). For the purposes of this study, this scale was subdivided into an Absolute scale, corresponding to published performance standards, and a Relative scale. The IP was instructed to use the Relative scale by assigning a grade based upon a comparison of the student's performance to that of other students at the same point in training. The standard of comparison for the Relative scale was totally subjective, based on the IP's accumulated teaching experience. This dual standard scale was used in

an attempt to reduce the variance typically encountered in rating scale judgements. Previous research suggested the use of the dual scale would provide increased measurement sensitivity as well as reducing inter- and intra-rater variability.

The original study protocol included use of the task observation data to be collected in both the ASPT and the T-37. However, during IP pretraining sessions, it was shown to be extremely difficult to make accurate observations of runway alignment from the right (IP position) of the ASPT due to the distortion of the visual display from that position. Therefore, these data were collected only on the two T-37 evaluation flights. The data card formats are presented in Appendix C.

Data Analysis

The automated data collected in the ASPT was analyzed using a multivariate analysis of variance technique (MANOVA) which provided an overall test of significance (Wilks-Lambda) and univariate stepdown F tests for each of the individual parameters. The RMS error scores were logarithmically transformed prior to analysis. Due to several bad data points and the unavailability of appropriate statistical programs, each measured repetition of each task was subjected to a separate MANOVA. The confidence limit established for the Wilks-Lambda was $p < .10$.

Relative and Absolute scale ratings of task proficiency given in the U, F, G, and E format were transformed into integer values 1, 2, 3, and 4, respectively. For ratings collected in the ASPT, data from each scale type were analyzed separately using a mixed design analysis of variance (ANOVA). From the ratings collected in the T-37, only Relative scale data were subjected to statistical analysis since visual inspection of the Absolute scale data revealed no mean differences with almost no variability. Due to incomplete data, a simple ANOVA was performed for each repetition of each task. The confidence limit was set at .05.

The original intent was to use a chi square analysis for each item of the categorical data collected on the evaluation flights. However, there were too many cells containing expected frequencies of zero. Therefore, the entry for each item from each task on each flight was converted to either "correct" or "incorrect." Thus, either a "high" or "low" data entry was treated as "incorrect." The frequencies of "correct" and "incorrect" items were summed across all the items forming the basis of a two (Correct vs. Incorrect) by three (Day vs. Night vs. Control) contingency table. A separate contingency table and associated analysis was computed for each task on each flight. The chi square statistic tests the likelihood that the observed distributions were due to chance. The coefficient of contingency, C, was also computed for each table. This measure gives an indication of the degree of association between the groups and their performance.

III. RESULTS

ASPT Data

Three questions are of interest when examining the outcomes of the ASPT traini . (a) Did the students' performance improve during the ASPT training? (b) Were there any performance differences as a function of the day versus night scenes used during training? (c) Did the students' performance improve differentially as a function of the day versus night scenes? Two types of dependent measures are available to address these questions: IP performance ratings and automated system state measures of task performance.

Table 1 presents mean values of the performance ratings by task, group, scale type, and repetition number. These data were analyzed using a mixed design analysis of variance (ANOVA) with Day versus Night groups as the between-group factor and trials as the repeated measures factor. The resulting F statistics and associated probability levels are presented in Table 2.

Table 1. Instructor Pilots' Mean Proficiency Ratings: ASPT Training

Task Condition		Trial 1		Trial 2		Trial 3	
		Relative	Absolute	Relative	Absolute	Relative	Absolute
Takeoff	Day	2.25	1.25	2.875	2.125	3.125	2.50
	Night	2.75	1.50	2.875	2.125	3.25	2.75
Full Stop Straight-In Approach	Day	1.875	1.375	3.375	2.50		
	Night	2.50	1.875	3.00	2.50		
Approach Portion of Touch-and-Go	Day	2.875	2.50	3.50	2.875		
	Night	3.125	2.50	3.125	2.625		
Takeoff Portion of Touch-and-Go	Day	2.75	2.125	3.25	3.0		
	Night	3.125	2.25	3.125	2.75		

Table 2. ASPT Training: IP Ratings - F Statistics

Task	Scale	Group (D vs N)	Trials	Group x Trials
Takeoff	R	<1	4.550*	<1
	A	<1	18.034*	<1
Full Stop Str-In	R	<1	11.200*	2.80
	A	<1	13.451*	1.098
Str-In App	R	<1	1.000	1.000
	A	<1	<1	<1
Touch-and-Go	R	<1	2.333	2.333
	A	<1	11.930*	<1

*$p < .01$.

The data collected by the ASPT automated performance measurement (APM) system were analyzed using a MANOVA. The means and standard deviations of the APM data and the results of the associated statistical analyses are presented by task in Tables 3 (Takeoff), 4 (Full Stop Straight-In Approach), and 5 (Straight-In Approach/Touch-and-Go). Due to occasional equipment failure, some of the data were lost. For this reason, each repetition of each task was analyzed separately. Rather than estimating mission data, the data were deleted for a subject selected at random from the opposite group. In these cases, n =7 instead of 8.

Table 3. Descriptive and Inferential Statistics
ASPT/Automated Measures: Takeoff

		Rotation Speed	Liftoff Speed	Heading Error	Attitude Error	Altitude Error
Trial 1						
Day	$\bar{X}$	77.62	87.74	.968	.860	5.56
	SD	6.33	2.38	.756	.292	.56
Night	$\bar{X}$	75.14	84.74	.574	.878	5.59
	SD	6.71	4.16	.828	.504	.39
$F_{(1, 12)}$		<1	2.728	<1	<1	<1
n =7, Lambda - Wilks $F_{(5, 8)}$ <1						
Trial 2						
Day	$\bar{X}$	78.06	86.65	.660	.842	5.38
	SD	6.29	5.36	.521	.471	73
Night	$\bar{X}$	77.29	86.91	.296	.620	5.17
	SD	9.23	6.92	.504	.266	.49
$F_{(1, 14)}$		<1	<1	2.016	1.350	<1
n =8, Lambda - Wilks $F_{(5, 10)}$ <1						
Trial 3						
Day	$\bar{X}$	78.44	88.03	.354	.577	5.14
	SD	7.32	4.35	.598	.335	.33
Night	$\bar{X}$	72.26	84.50	.411	.278	5.20
	SD	5.36	4.31	.480	1.24	.57
$F_{(1, 14)}$		3.711*	2.670	<1	<1	<1
n =8, Lambda - Wilks $F_{(5, 10)}$ <1						

*p <.10.

Table 4. **Descriptive and Inferential Statistics ASP 'Automated Measures Full Stop Straight-In Approach**

		Final Approach			Glidepath		
		Altitude Error	Centerline Error	Air Speed Error	Glidepath Error	Centerline Error	Air Speed Error
Trial 1							
Day	$\overline{X}$	4.30	4.56	1.18	.274	3.32	1.56
	SD	.45	.44	.76	.692	.94	.82
Night	$\overline{X}$	4.23	4.73	.88	-.429	3.92	1.13
	SD	.38	.38	.77	.526	.55	.68
$F_{(1,12)}$		<1	<1	<1	4.584*	2.088	1.150
n =7, Lambda - Wilks $F_{(6,7)}$ =1.203 p <.402							
Trial 2							
Day	$\overline{X}$	3.86	4.39	1.19	-.539	3.08	.737
	SD	.36	.57	.37	.624	.62	.577
Night	$\overline{X}$	3.42	4.60	.92	.018	3.51	.732
	SD	.63	.46	.55	.424	1.04	.326
$F_{(1,14)}$		2.860	<1	1.363	4.373*	1.07	<1
n =8, Lambda - Wilks $F_{(6,9)}$ =2.569 p <.098*							

*p <.10.

Table 5. **Descriptive and Inferential Statistics ASPT/Automated Measures Straight-In Approach/Touch-and-Go**

		Final App Alt Error (LOG RMS)	Centerline Error (LOG RMS)	Glidepath Final App A/S Error (LOG RMS)	Glidepath Error (LOG RMS)	Takeoff Centerline Error (LOG RMS)	Takeoff Glidepath A/S Error (LOG RMS)	Heading Error (LOG RMS)	Attitude Error (LOG RMS)	Takeoff Alt Error (LOG RMS)
Trial 1										
Day	$\bar{X}$	3.75	4.39	.78	-.308	3.59	.723	.71	.82	5.49
	SD	.21	.52	.78	.635	.45	.36	.59	.38	.69
Night	$\bar{X}$	3.79	4.82	.53	-.092	3.89	.99	.35	.94	5.49
	SD	.26	.28	.41	.42	.64	.63	.38	.21	.40
$F_{(1,14)}$		<1	4.232	<1	<1	1.083	1.099	2.115	<1	<1
n =8, Wilks - Lambda $F_{(9,6)}$ <1										
Trial 2										
Day	$\bar{X}$	3.44	4.53	.99	-.41	3.34	.80	.56	.69	5.41
	SD	.47	.33	.35	.44	.61	.56	.67	.19	.55
Night	$\bar{X}$	3.63	4.59	.68	-.53	3.35	.69	.71	.87	5.15
	SD	.57	.38	.56	.69	.87	.59	.47	.22	.38
$F_{(1,14)}$		<1	<1	1.682	<1	<1	<1	<1	3.093	1.291
n =8, Wilks - Lambda $F_{(9,6)}$ <1										

*$p < .10$.

The results of the performance rating analyses provide information with respect to all three of the questions of interest, whereas the analyses of the APM data are only relevant to the Day versus Night comparisons. The results of the ASPT training phase may be summarized as follows. (a) Student performance improved significantly on the Takeoff, Full Stop Straight-In, and the Takeoff portion of the Touch-and-Go. (b) There were no differences between the Day and Night groups as assessed by instructor pilot performance ratings. Analyses of the APM data indicated initial superiority of the Night group on the single parameter of control on the glidepath angle of descent on the Full-Stop Straight-In Approach. However, the Day group was significantly better than the Night group on that parameter and the task as a whole by the next measurement point. There were no reliable performance differences on the Takeoff or Touch-and-Go. (c) There was no tendency for performance to be differentially influenced by the differences in day and night scenes.

T-37 Transfer Evaluation

There are two questions of primary interest concerning student performance in the aircraft. (a) Were there any reliable differences between the performance of the Day and Night group? (b) Did either or both of the ASPT trained groups perform better than the Control group. Questions concerning negative transfer indications for the Night group and learning differences between the three groups are also of interest. Deviations in the study protocol occurred which affected the ability to address these questions as originally planned. These items will be discussed briefly before proceeding with a presentation of the data.

As originally designed, the transfer evaluations were to consist of at least one repetition of each task on each of the two evaluation flights. However, for various reasons, these goals were not consistently accomplished. The biggest problem occurred on the Approach portion of the Full Stop or Touch-and-Go tasks. Apparently, the students were given the opportunity to fly one or the other, but not both maneuvers. The IPs were more willing to allow the students to fly the takeoff portion of the Touch-and-Go. As a consequence, the data from the Approach segments of the Full Stop and Touch-and-Go were collapsed and treated as the same task. Another consequence of the incomplete data collection was the inability to use a mixed design ANOVA on the rating data. Separate ANOVAs of each repetition were used instead.

Two types of information were collected by IPs: (a) relative and Absolute performance ratings as used in the ASPT phase, and (b) criterion-referenced observations of aircraft control. (In some instances, the IP marked more than one alternative for a given item, e.g., circled -50, 0, and + 50 feet on altitude control. When this occurred, each circled option was treated as an integer for each category in the contingency tables.) Tables 6, 7, and 8 present the 2 by 3 contingency tables and associated statistics. Table 9 presents the descriptive and inferential statistics for performance ratings.

Day vs. Night. The results of the a priori "t" tests comparing the performance ratings (Relative scale only) are the only direct source of information regarding the differences between the Day and Night groups. The results of these analyses indicate that there were no significant differences between the groups on any of the tasks on either evaluation flight.

Training Effectiveness. Comparison of the performance of the Control group which did not receive ASPT training with the performance of the ASPT-trained students provides the indication of training effectiveness. The results of the a priori "t" tests of the Day and Night groups combined versus the Control group, the "F" tests, and to an extent, the chi square analyses provide information regarding this issue. However, the rating data obtained on the Absolute scale is equally valuable in

Table 6. Task Item Analysis: Takeoff

		Correct	Incorrect
a.	First observation		
	Control	10	38
	Night	16	31
	Day	15	32
df =2, χ^2 =2.33 (p <.50), C =.13			
b.	Second observation		
	Control	14	34
	Night	27	21
	Day	28	22
df =2, χ^2 =8.75 (p <.02), C =.24			

Table 7. Task Item Analysis: Straight-In Approach

		Correct	Incorrect
a.	First observation		
	Control	17	55
	Night	22	52
	Day	28	44
df =2, χ^2 =4.00 (p <.10), C =.13			
b.	Second observation		
	Control	27	51
	Night	35	43
	Day	26	33
df =2, χ^2 =8.75 (p <.02), C =.10			

Table 8. **Task Item Analysis: Touch-and-Go/ Takeoff Segment**

		Correct	Incorrect
a.	First observation		
	Control	8	26
	Night	14	34
	Day	14	21
df =2, χ^2 =2.29 (p <.50), C = .14			
b.	Second observation		
	Control	14	42
	Night	26	23
	Day	11	31
df =2, χ^2 =10.96 (p <.01), C =.24			

Table 9. **Instructor Pilot Mean Ratings and Analysis T-37**

Task	Trial	Scale	Control	Night	Day	F	t(D vs N)	T(D/N vs C)
Takeoff	1	R	1.625 (8)*	2.125 (8)	2.714 (7)	3.638**	1.279	-2.2099**
		A	1.0	1.0	1.25	NC**	NC	NC
	2	R	2.00 (8)	2.625 (8)	2.857 (7)	2.041	<1	-1.986**
		A	1.50	2.12	1.75	NC	NC	NC
Straight-In Approach	1	R	1.625 (8)	1.750 (8)	2.125 (8)	<1	<1	<1
		A	1.0	1.0	1.0	NC	NC	NC
	2	R	2.125 (8)	2.750 (8)	2.429 (7)	<1	<1	-1.157**
		A	1.37	2.00	1.57	NC	NC	NC
Takeoff Portion of Touch-and-Go	1	R	1.6 (5)	1.857 (7)	2.20 (5)	<1	<1	<1
		A	1.0	1.0	1.0	NC	NC	NC
	2	R	1.875 (8)	1.857 (7)	2.167 (6)	<1	<1	<1
		A	1.120	1.0	1.33	NC	NC	NC

*Sample size.
**$p \leq .05$.
***Not computed.

this regard. As far as the Absolute rating is concerned, there was virtually no positive (or negative) transfer of training effect. The results of the "t" and "F" tests on the Relative rating data reveal that positive transfer occurred only on the Takeoff task. From the chi square analyses, the only instance which revealed a non-chance distribution was the Takeoff portion of the Touch-and-Go task. Although more difficult to interpret, it would appear that the performance of the Night group was superior to that of the Control group. This difference is not consistent with the ordinal rankings of the groups on the rating data.

With respect to negative transfer, there were no indications from the data or from the postflight interviews with the IPs that any potentially hazardous flying skills resulted from the ASPT training (Day or Night conditions).

Learning. Due to the incomplete data returns, the statistical techniques used do not provide a direct test of the magnitude of skill acquisition between the two evaluation flights. It is evident from a visual inspection of the data that all three groups improved. The more interesting experimental question concerns the differential learning rates that may be associated with the ASPT training, *per se*, or the type of visual display. It appears that the Day and Control groups improved approximately equivalent amounts from the first to second evaluation flight, with the Night group showing slightly larger gains for the Takeoff and Straight-In Approach tasks on the Absolute scale.

IV. DISCUSSION

The study was designed to provide preliminary information regarding the transfer of training of a restricted field-of-view night visual scene for application to the IFS used for UPT. In addition, a comparison was made between the night scene and the day scene available on the ASPT. Both visual scenes were produced by CGI system.

In order to determine the transfer value of the night scene or to assess the differential effectiveness of the day versus night scenes, transfer of training must first be demonstrated. This was accomplished by comparing the performance in the aircraft of students who were trained in the ASPT (Day or Night condition) with the performance of students who did not receive ASPT training, i.e., the Control group. The first issue, then, to be addressed concerns the evidence that any transfer of training actually occurred.

The data on the performance ratings provided on the Absolute scale do not show any difference in performance of the three groups. The initial performance of all three groups on all three tasks was judged to be unsatisfactory. Although performance ratings increased somewhat by the fifth flight, there was very little difference between the three groups. Thus, according to this data source, one would have to conclude that no transfer of training occurred. The data obtained on the Relative scale and the task observation information reflect greater sensitivity to group differences and training effects. The results of analyses on these data indicate that the two groups trained in the ASPT performed the Takeoff task reliably better than did the Control group. Their performance on the other tasks tended to be rated higher than the Control group but these differences were not statistically significant. The most reasonable conclusion regarding the extent of transfer demonstrated in this study would be that a small positive transfer effect was demonstrated for the Takeoff task.

The relatively small magnitude of demonstrated transfer is particularly surprising in light of the fact that significant improvement in performance was demonstrated by both experimental groups during the ASPT training phase. By the end of the ASPT training, student performance was rated

high in the Fair range on the Absolute scale and in the Good range on the Relative scale. Thus, while student performance and skill acquisition seemed satisfactory during the ASPT training, the performance levels were not sustained in transition to aircraft flight. Clearly, the transfer was not on a one-to-one basis as many training program designs expect prior to the introduction of a modern simulation device into a training program.

If transfer is less than the one-for-one tradeoff or if the simulator training does not elevate performance in the aircraft by at least a full grade on the operational grading scale, the device is often considered worthless by the operational training community. However, often times such disappointing findings are the result of inadequate performance assessment techniques and of underestimating the importance of training technology. The operational grading scales are generally designed to detect large changes in proficiency and are, by design, relatively insensitive to smaller changes in performance. Thus, while simulator training may not result in a full grade change in performance (as from Unsatisfactory to Fair), the training may elevate performance within a category (from the bottom to the top of a grade category). These differences may have significant pragmatic implications for a training program, especially if similar increments occurred continuously throughout each block or phase of a syllabus. However, by many current operational measurements standards, these effects would not be detected. This kind of problem is particularly critical to design and procurement decisions based on the results of the Operational Test and Evaluation process. The results of the present study reflect a small transfer effect which in itself may be trivial but could have a significant cumulative effect when spread over the entire basic contact phase of training. The results of this study also demonstrate the difference in sensitivity of varying assessment techniques.

With respect to the effectiveness of the night scene for application to daytime flight training, the results show that the Night group consistently performed better than the Control group although the differences were small for the Straight-In and Touch-and-Go. There were no indications of hazardous elements of either the glidepath or flare segments of the approach. However, given the relatively low level of transfer obtained in the present study, it is difficult to draw firm conclusions regarding the training potential of the night scene. Improvements in simulator training strategies can reasonably be expected to enchace the magnitude of transfer, but it is not clear to what extent. It is difficuit, if not impossible, to make an evaluation of any training device independent of the training methodology used in the evaluation.

A comparison between the night scene and the model board scene would be particularly useful considering the results of the Navy NCLT study (Brictson & Burger, 1976) and that of the Air Force KC-135 study (Thorpe et al., 1978). The Navy study demonstrated a large positive transfer effect from the simulator to night flight conditions but no transfer effect to daytime conditions i.e., transfer specific to night flight. The Air Force study offered evidence that the model board system was inferior to day and night CGI systems on the final approach maneuver. Since the Air Force study did not employ a control group. it is not possible to assess the overall magnitude of transfer. However. comparisons were made late in the operational training program with a pseudo-control indicating that all the groups which received the simulator pretraining performed better than pilots who had not participated in the study. Additionally, it was found that the day-color CGI group had maintained a superior level of performance when compared to the night and model board groups.

Considering the data available to date, it is unclear how effective a simulated night visual scene is for transfer to day flight. The present study demonstrates a small level of transfer; the KC-135 shows a larger level of transfer: the Navy A-7 study did not demonstrate any positive daytime effect, but there was a significant nighttime effect. Equally as pertinent for Air Training Command concerns is the fact that the model board system, the type currently in use on the IFS, was not as

effective as the night scene in the KC-135 study. Therefore, the most logical step for Air Training Command would be to conduct a direct model board/night scene comparison within the operational training context.

V. CONCLUSIONS/RECOMMENDATIONS

1. A small positive transfer-of-training effect was observed for both the Day and Night experimental groups.

2. There were no reliable differences between the Day and Night groups in terms of their performance in the aircraft.

3. There was no evidence of negative transfer associated with the performance of the night group.

4. In order to maximize transfer-of-training benefits, implementation of a night visual scene should be associated with more extensive simulator training than was provided in the present study.

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APPENDIX A: ASPT SCENARIO CONTENT

MISSION 1

TAKEOFF	DEMONSTRATION
TAKEOFF	3
TAKEOFF	APM
STRAIGHT-IN FS	DEMONSTRATION
STRAIGHT-IN FS	3
STRAIGHT-IN FS	APM
TAKEOFF	2
TAKEOFF	APM

MISSION 2

TAKEOFF	2
STRAIGHT-IN FS	2
STRAIGHT-IN TG	DEMONSTRATION
STRAIGHT-IN TG	3
STRAIGHT-IN TG	APM
STRAIGHT-IN FS	2

MISSION 3

TAKEOFF	3
TAKEOFF	APM
STRAIGHT-IN FS	4
STRAIGHT-IN FS	APM
STRAIGHT-IN TG	4
STRAIGHT-IN TG	APM

APPENDIX B: IP INFORMATION GUIDE NIGHT VISUAL SCENE EVALUATION

The objective of this study is to evaluate the training value of a night visual simulator scene for daytime aircraft training. As the instructor pilot, you are the primary evaluator. The purpose of this guide is to introduce you to the study objectives, make you aware of the observations that must be made by you to effectively evaluate the student and to help you understand the use of the in-cockpit grade cards.

We are asking that you make rather detailed observations on the student's performance on three maneuvers: takeoff, straight-in approach and landing, and the straight-in's in combination with the touch-and-go. These observations will be collected by you on the second (B2101) and fifth (B2202) sorties. It is essential that the student not have any "hands on" control at these tasks until the second (B2101) sortie. In addition to collecting the maneuver specific data, you will be interviewed following the student's fifth sortie on your subjective comments concerning the student's performance. These interviews are for research purposes only and will be kept strictly confidential.

Limits of the Training in ASPT:

1. No X-wind training
2. Little procedural training
3. Takeoff continued to approximately 1900' MSL
4. All landings trained to the center of the runway
5. Straight-in training initiated at approximately five miles out.

NOTE: Students who have been trained in ASPT will have had extensive straight-in, takeoff, and touch-and-go training, so please allow those particular students to fly with as little assistance as possible, *but of course not to compromise flying safety*!

I have included an enlargement of the takeoff, straight-in approach and landing, and touch-and-go grade cards that you will use in the aircraft. We would like the data recorded on these cards as soon as possible after the student performs the maneuver; however, do not sacrifice clearing or aircraft control of any kind to complete them. The cards are generally self-explanatory, but some questions have come up regarding unusual circumstances. For example, during the T/O groundtrack control, you should mark left, on, or right. If the student does not over or under control, don't mark the corresponding blocks. On the other hand, if the student does over or under control, mark the appropriate box and indicate whether left, on, or right best represents the performance. During the landing from the straight-in, make sure you indicate whether the flare was smooth or abrupt in addition to whether the student flared high, on, or late. Also, be sure to indicate whether the straight-in was a touch-and-go or full stop. Use your best judgement when filling out the cards and make sure that each item has been marked. Any item not graded will make it very difficult for us to evaluate your student's performance. If you have to take aircraft control during any part of the maneuver, *please* include it in your comments at the bottom of the card. Questions have come up about the overall score. I'm sure you all understand the difference, but to reinforce your understanding, we want the absolute grade to reflect the student's performance against the perfect maneuver. Relative score should reflect the performance as a measure of what the student has learned up to this point in training. If there are any questions concerning grading or use of the card, please contact Dan Catanco at 6604 or Lee Lesher/DOR 2468. Before you fly with your student on a data ride, please read this guide and the data cards. If you are unsure, ask! Thank you for your help.

APPENDIX C: SUMMARY TASK ITEM ANALYSIS

I. Takeoff

A 1. Takeoff Roll/Ground Track Control

		Left	On	Right
Control	1st Observation	4	2	2
	2nd Observation	2	3	3
Night	1st Observation	2	3	3
	2nd Observation	4	4	2
Day	1st Observation	2	2	3
	2nd Observation	3	3	2

F2. Nose wheel Steering

		Overcontrol	Undercontrol	Appropriate
Control	1st Observation	4	1	3
	2nd Observation	0	3	5
Night	1st Observation	3	3	2
	2nd Observation	1	2	5
Day	1st Observation	3	3	2
	2nd Observation	2	3	3

B. Rotation Speed

		Low	On	High
Control	1st Observation	0	0	8
	2nd Observation	1	1	6
Night	1st Observation	0	2	6
	2nd Observation	0	6	2
Day	1st Observation	1	4	3
	2nd Observation	1	7	0

C. Liftoff Speed

		Low	On	High
Control	1st Observation	3	3	2
	2nd Observation	4	1	3
Night	1st Observation	3	3	1
	2nd Observation	4	4	0
Day	1st Observation	5	3	0
	2nd Observation	3	5	0

D. Pitch Attitude

		Low	On	High
Control	1st Observation	5	0	3
	2nd Observation	4	0	4
Night	1st Observation	1	1	6
	2nd Observation	0	3	5
Day	1st Observation	0	1	7
	2nd Observation	1	4	3

E. Runway Alignment after Takeoff

		Left	On	Right
Control	1st Observation	0	2	6
	2nd Observation	2	4	2
Night	1st Observation	0	5	5
	2nd Observation	2	5	1
Day	1st Observation	2	3	3
	2nd Observation	1	4	3

II Straight-In Approach (Either Full Stop or TG)

A. Runway Alignment Prior to Descent

		Left	On	Right
Control	1st Observation	5	0	3
	2nd Observation	3	2	3

Night	1st Observation	3	2	3
	2nd Observation	3	3	2
Day	1st Observation	2	4	1
	2nd Observation	2	5	0

B. Altitude Prior to Descent

		−100<	−100'	−50'	0'	50'	100'	> 100'
Control	1st Observation	3	2	1/3	1-1/3	1/3	0	1
	2nd Observation	3-1/2	1-1/2	1-1/3	1-1/3	1/3	0	0
Night	1st Observation	1	6	0	0	0	1	0
	2nd Observation	0	2	3	2	1	0	0
Day	1st Observation	1	4	1-1/3	1/3	1/3	0	1
	2nd Observation	1-1/2	2-1/2	2	1	0	0	0

C. Glidepath Intercept Point

		Early	On	Late
Control	1st Observation	1	3	4
	2nd Observation	2	4	2
Night	1st Observation	1	3	4
	2nd Observation	0	6	2
Day	1st Observation	2	4	2
	2nd Observation	1	4	2

D. Glidepath Control

1. Altitude

		Low	On	High
Control	1st Observation	2	2	3
	2nd Observation	2	3	3
Night	1st Observation	2	1	3
	2nd Observation	1	2	5
Day	1st Observation	4	5	3
	2nd Observation	2	2	3

2. Airspeed

		Low	On	High
Control	1st Observation	3	1	4
	2nd Observation	2	3	3
Night	1st Observation	1	3	4
	2nd Observation	1	2	5
Day	1st Observation	3	3	2
	2nd Observation	2-1/3	1/3	4-1/3

3. Runway Alignment

		Left	On	Right
Control	1st Observation	5	0	3
	2nd Observation	4	2	2
Night	1st Observation	3	4	1
	2nd Observation	0	7	1
Day	1st Observation	1	6	1
	2nd Observation	1	5	1

E. Flare

1. Position

		High	On	Low
Control	1st Observation	4	2	1
	2nd Observation	1	2	5
Night	1st Observation	5	0	2
	2nd Observation	2	1	5
Day	1st Observation	4	1	3
	2nd Observation	5	0	0

2. Technique

		Abrupt	Smooth
Control	1st Observation	4	3
	2nd Observation	5	3
Night	1st Observation	4	3
	2nd Observation	2	4
Day	1st Observation	2	2
	2nd Observation	1	3

F. Touchdown

1. Airspeed

		Low	On	High
Control	1st Observation	2	1	3
	2nd Observation	6	2	0
Night	1st Observation	0	2	4
	2nd Observation	6	2	0
Day	1st Observation	1	1	5
	2nd Observation	2	2	1

2. Runway Alignment

		Left	On	Right
Control	1st Observation	1	4	1
	2nd Observation	3	5	0
Night	1st Observation	2	4	0
	2nd Observation	2	6	0
Day	1st Observation	0	4	3
	2nd Observation	0	4	1

III. Touch-and-Go (Takeoff portion)

A. Takeoff Attitude

		Low	On	High
Control	1st Observation	1	0	4
	2nd Observation	3	0	5
Night	1st Observation	1	1	5
	2nd Observation	2	4	1
Day	1st Observation	1	1	3
	2nd Observation	1	1	4

		Nose Wheel Touch	Lift Early	Appropriate
Control	1st Observation	1	2	2
	2nd Observation	3-1/2	4-1/2	0
Night	1st Observation	1	3	3
	2nd Observation	2	1	4
Day	1st Observation	1-1/2	3-1/2	0
	2nd Observation	1-1/2	3-1/2	1

2. Directional Control

		Low	On	High
Control	1st Observation	1	1	3
	2nd Observation	4	4	0
Night	1st Observation	4	3	0
	2nd Observation	0	3	4
Day	1st Observation	3	2	0
	2nd Observation	3	1	2

		Overcontrol	Undercontrol	Appropriate
Control	1st Observation	2	2	1
	2nd Observation	1	4	3
Night	1st Observation	1	3	3
	2nd Observation	2	2	3

Day	1st Observation	1	2	2
	2nd Observation	1	4	1

C. Liftoff Speed

		Low	On	High
Control	1st Observation	1	2	1
	2nd Observation	4	1	3
Night	1st Observation	5	0	1
	2nd Observation	3	4	0
Day	1st Observation	3	2	0
	2nd Observation	4	2	0

D. Pitch Attitude

		Low	On	High
Control	1st Observation	0	1	4
	2nd Observation	2	1	5
Night	1st Observation	0	0	7
	2nd Observation	1	3	3
Day	1st Observation	1	2	2
	2nd Observation	0	2	4

E. Runway Alignment After Takeoff

		Left	On	Right
Control	1st Observation	1	1	3
	2nd Observation	3	5	0
Night	1st Observation	1	4	2
	2nd Observation	1	5	1
Day	1st Observation	0	4	1
	2nd Observation	0	1	1